^{53}Mn-^{53}Cr SYSTEMATICS OF R-CHONDRITE NWA 753.

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Introduction: Chondrules and chondrites are interpreted as objects formed in the early solar system, and it is important to study them in order to elucidate its evolution. Here, we report the study of the Mn-Cr systematics of the R-Chondrite NWA753 and compare the results to other chondrite data. The goal was to determine Cr isotopic and age variations among chondrite groups with different O-isotope signatures. The ^{53}Mn-^{53}Cr method as applied to individual chondrules [1] or bulk chondrites [2] is based on the assumption that ^{53}Mn was initially homogeneously distributed in that portion the solar nebula where the chondrules and/or chondrites formed. However, different groups of chondrites formed from regions of different O-isotope compositions. So, different types of chondrites also may have had different initial ^{53}Mn abundances and/or Cr isotopic compositions. Thus, it is important to determine the Cr isotopic systematics among chondrites from various chondrite groups. We are studying CO-chondrite ALH83108 and Tagish Lake in addition to R-Chondrite NWA753. These meterorites have very distinct O-isotope compositions (Figure 1).

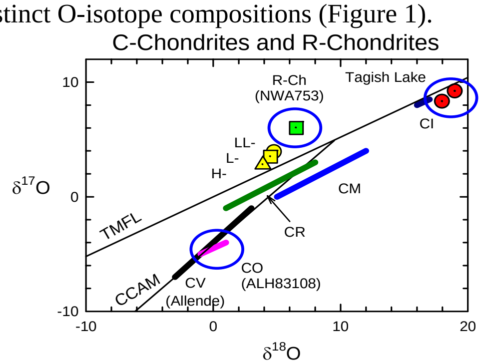

Figure 1. Comparison of O-isotope composition of R-chondrite NWA 753 to those of other chondrite groups.

Samples, Analytical Procedures, and Results: NWA 753 is a rare Rumuruti-type chondrite (R 3.9). A thin slab of the chondrite, weighing ~650 mg, was kindly allocated to us by T. Nakamura for this study. The sample is brownish and contains many small (<1mm diameter) white chondrules. The sample was cleaned in ethyl alcohol and sonicated for 10 minutes. Then we broke the sample and picked out ~ 110 mg "clean" chips for the Mn-Cr study. In order to eliminate possible post-crystallization, pre- or terrestrial, contamination, one bulk rock sample was further cleaned by washing in 2N HCl with sonication for 10 minutes, producing the whole rock residue WR(r) and leachate WR(l). Another bulk rock sample (WR) was not washed with HCl. Chemical procedures are described in [1]. The ^{53}Cr/^{52}Cr and ^{54}Cr/^{52}Cr isotopic measurements, normalized to ^{50}Cr/^{52}Cr =0.0518585, were made on a Finnigan-MAT 261 multi-collector mass spectrometer. Multiple (6-13) runs were obtained for each sample. The ε^{53}Cr and ε^{54}Cr values (deviations in 10^4 of sample ^{53}Cr/^{52}Cr and ^{54}Cr/^{52}Cr relative to their respective standard ^{53}Cr/^{52}Cr and ^{54}Cr/^{52}Cr values) were calculated. Using the Williamson program to regress sets of ε^{53}Cr and their corresponding ε^{54}Cr data, we obtained ε^{53}Cr values, readjusted to ε^{54}Cr=0, for each sample of NWA 753. The Mn and Cr concentrations were made by ICP-MS on an aliquot (~10%) of the sample solution (Table 1.)

Table 1. Mn-Cr Analytical Results for NWA 753

Sample[a]	^{55}Mn/^{52}Cr[b,c]	$\varepsilon(^{53}$Cr$)$[c,d]
R-chondrite :		
NWA753 WR	0.709±0.036	0.39±0.10
NWA753 WR(r)	0.707±0.036	0.31±0.08
NWA753 WR(l)	2.90±0.15	0.25±0.11
	Wtd avg =	0.32±0.05

[a]WR=whole rock, r,l=acid-washed residues, leachates.
[b]Mn and Cr Determined by ICP-MS (analyst C.M. Kuo of Wyle Labs.), ±~5%.
[c]Uncertainties correspond to last figures and represent $\pm 2\sigma_m$ error limits.
[d]ε-values calculated relative to standard ^{53}Cr/^{52}Cr runs.

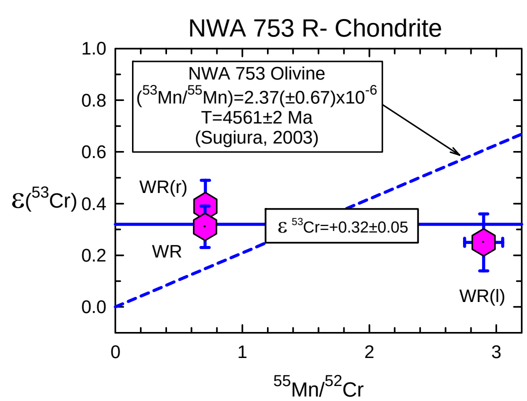

Figure 2. Mn-Cr isochron plot for NWA 753.

Mn-Cr internal isochron for NWA 753: The ε^{53}Cr and ^{55}Mn/^{52}Cr data for three samples of NWA 753 are shown in Figure 2. The unwashed WR and acid-washed WR(r) bulk samples contain most of the Cr and appear to have slightly higher ε^{53}Cr than the leachate WR(l), which contains only ~15% of the bulk Cr. However, all three samples have the same ε^{53}Cr within analytical uncertainties despite a 3-fold variation in ^{55}Mn/^{52}Cr between the whole rock and leachate samples. These samples do not show the old age (dotted isochron) defined by fayaltic olivine grains in NWA 753 [3]. However, NWA 753 is brecciated, and only the more primitive lithology was analysed by [3]. Moreover, our leachate sample may contain some alteration products, commonly found in desert meteorites, and which may have compromised its Cr isotopic composition. Further studies will be needed. We tentatively assign the weighted mean value ε^{53}Cr=+0.32±0.05 to NWA 753. This value is virtually the same as +0.31±0.08 for the acid-washed bulk sample.

Possible O-Cr isotopic correlations: Figure 3 compares ε^{53}Cr for NWA 753 to values for L-, LL-, H-, and CO-chondrites plotted against Δ^{17}O for these chondrite groups. There is a hint of a small positive trend of ε^{53}Cr with Δ^{17}O. More precise analyses of CO-chondrites are required to verify this trend. Reasons why such a trend might exist include: (a) All the chondrites could have formed at the same time with variable Mn/Cr; (b) R-chondrites could have formed first, before some ^{53}Mn had decayed; (c) ^{53}Mn might have been heterogeneously distributed within the early solar system. However, these data also can be considered to be nearly the same within error limits, and consistent with homogeneous distribution of ^{53}Mn.

To aid in examining these alternatives, Figure 4 shows Mn-Cr isotopic data from the JSC laboratory for C-chondrites and the L-, LL-, and H-chondrites for which averaged data are shown in Figure 3. Five bulk carbonaceous chondrites satisfy an isochron relationship for initial $(^{53}Mn/^{55}Mn)_I$ = (6.5 ± 3.3) × 10^{-6} and $\varepsilon(^{53}Cr)_I$ = = -0.18 ± 0.18. This result appears to be within error limits of initial $(^{53}Mn/^{55}Mn)_I$ = (8.5 ± 1.5) × 10^{-6} and $\varepsilon(^{53}Cr)_I$ = ~-0.21 reported by [2] for carbonaceous chondrites. H-chondrites plot near the carbonaceous chondrite isochron; recent data for Tieschitz plot at highest ^{55}Mn/^{52}Cr and are the most precise. The carbonaceous chondrite isochron implies an absolute age of formation of the parent bodies T_{LEW}= 4566±4 Ma when compared to $(^{53}Mn/^{55}Mn)_I$ = 1.44±0.07 x 10^{-6} for Lewis Cliff 86010 (LEW) [4], using 4558 Ma as the age of LEW [5].

Conclusions: The ~4566 Ma age for C-chondrites agrees with the CAI age reported by [6] and widely accepted as the age of the solar system. Also, the R-, L-, and LL-chondrite Mn-Cr data lie above the C-chondrite isochron, suggesting either slightly higher initial ^{53}Mn abundances in R-, L- and LL-chondrites; i.e., an initially heterogeneous distribution of ^{53}Mn in the early solar system [7], or variations in initial Cr-isotopic compositions, possibly correlated to O-isotope variations. More and higher precision data will be needed to resolve these possiblilities, and could show both ^{53}Mn and ^{53}Cr/^{52}Cr to have been homogeneous in the region where the parent bodies of these meteorites formed.

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References: [1] Nyquist L. E. et al. (2001) *MAPS 36*, 911-938. [2] Shukolyukov A. et al. (2003) *LPS XXXIV*, #1279. [3] Sugiura N. (2003) *GCA 67*, A453. [4] Nyquist L. E. et al. (1994) *Meteoritics 29*, 872-885. [5] Lugmair G. W. and Galer S. J. G. (1992) *GCA 56*, 1673-1694. [6] Amelin Y. et al. (2002) *Science*, 297, 1678-1683. [7] Shukolyukov A. and Lugmair G. W. (2004) *GCA 68*, 2875-2888.

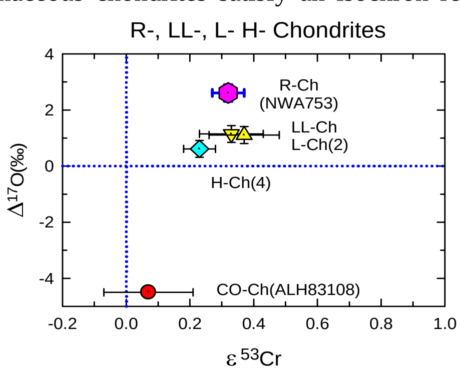

Figure 3. Δ^{17}O vs. ε^{53}Cr for R-, L-, LL-, H-, and CO-chondrites. Data are averages from [1] and JSC (unpub.)

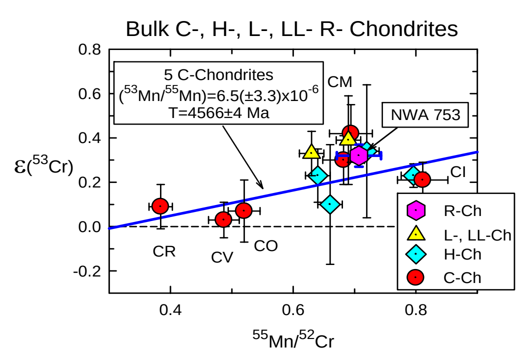

Figure 4. ε^{53}Cr vs. ^{55}Mn/^{52}Cr evolution diagram for bulk C, H, LL, and R chondrites. (Data from [1] and JSC (unpub.)